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The DORIC Program: The Telecom/DSTO Research ATM Network

Keith L. Northeast

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ABSTRACT

This report gives an overview of the architecture and philosophy behind the Telecom/DSTO Research ATM Network. Emphasis is placed on describing the planned enhancements to the network in the near future.

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EXECUTIVE SUMMARY

The DSTO (Defence Science and Technology Organisation) Research ATM Network is a component of a wider DSTO research initiative called the DORIC (Defence Organisation Integrated Communications) program. The purpose of this program is to research, define and demonstrate a goal architecture and associated technologies which will enable the integration of Defence Organisation communications in a timely and cost effective manner.

Presently, the Research ATM Network spreads across four capital cities in the south-east of Australia. Further expansion of the Network will include the installation of switching nodes at selected military bases for network test and evaluation. The first phase of this process will be used for support of the Kangaroo 95 exercise in 1995. Global expansion will also be realised due to the linking of research ATM networks in Australia, USA Canada and the UK under The Technical Cooperation Program (TTCP).

The DSTO Research ATM Network provides the opportunity to conduct research into aspects of next generation Defence communications networks not being immediately addressed within the civil arena.

The knowledge gained will be invaluable in the future network planning process to develop a goal architecture for Defence. It will also be relevant to forming the migration strategies which will outline the evolution of current networks to the future architecture.

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The author graduated in 1963 with a Batchelor of Technology degree in Electronics Engineering from the University of Adelaide whilst in the employ of EMI Electronics Pty. Ltd. Whilst with that company, he performed systems/design engineering on various military weapons sensing and communications systems. In 1982, he commenced work with Codan Pty. Ltd. as leader of the Digital Design Section with responsibility for the design of a digital satellite earth station network. Since 1988, he has been employed by the Australian Department of Defence as a senior research engineer and has spent the last 2 years managing the development of the DSTO Experimental ATM Research network.

Contents

1. Introduction

The DSTO (Defence Science and Technology Organisation) Research ATM Network serves as a tool to facilitate research and promote understanding of how a unified multi-media network can best be utilised in the Australian defence arena.

The ATM Network is a component of a wider DSTO research initiative called the Defence Organisation Integrated Communications (DORIC) program. The purpose of this program is to research, define and demonstrate a goal architecture and associated technologies which will enable the integration of Defence Organisation communications in a timely and cost effective manner at three levels, namely :

- Integration of differing traffic types
- Integration of different purpose-built networks
- Integration of Defence networks with the future civil communications infrastructure

This represents a departure from the current military communications architecture where there are very low levels of integration of different traffic types and very little integration with commercial communications networks. The result is a relatively inflexible and inefficient architecture.

While integration and compatibility with the civilian worlds are key issues, Defence still has certain network requirements that are unique. For example, in tactical networks there is a requirement to use HF radio and satellite trunks which have very low bit rates compared to optical fibre based trunks. There are also issues such as security, reliability, priority and pre-emption which are of importance in Defence networks. All these areas serve as focal points for the research which the DSTO Research ATM Network supports.

2. Aim

This report gives an overview of the architecture and philosophy behind the Telecom/DSTO Research ATM Network. Emphasis is placed on describing the planned enhancements to the network in the near future and its role in support of the development of improved capabilities in Military communications facilities.

3. The Goal Architecture

The identification of a goal architecture was the first milestone of the DORIC program. From this process, a multiplexing and routing technique known as Asynchronous Transfer Mode (ATM) was identified as the most likely future networking technology to meet ADF requirements. ATM is a connection oriented protocol providing end to end virtual circuits with information carried in 53 byte cells each consisting of a 5 byte header and a 48 byte payload. The 48 byte payload size was chosen as a compromise to minimise packetisation delay for real-time traffic without imposing an excessive header overhead. Headers or trailers required by higher layer protocols are carried in the cell payload field along with user data.

A user's data is segmented into cells which are multiplexed into a constant rate output cell stream for transmission between network nodes. Idle cells are inserted if necessary to make up the rate. Segmentation is performed by an ATM Adaptation Layer (AAL) which functions at user interfaces in a manner which enables reassembly into the original format by the AAL at the destination.

Before a session can begin, a set up procedure establishes a virtual circuit by initialising tables of routing information in all switching nodes along the chosen end-to-end path and creating circuit identifiers which are carried in the headers of all cells associated with that circuit. These identifiers are mapped by the switch node tables to correctly route the cells through to their destination. This technology can support all types of traffic including data and real-time streams such as audio and video. The differing loss and delay sensitivities of data types are indicated through a bit in a cell header field which is recognised by the switching nodes. Appropriate buffering strategies are then applied to prioritise handling in the case of real-time cells or reduce the likelihood of loss for data carrying cells.

An important attribute of ATM is that it is not locked into any physical medium or speed and inherently provides bit-rate independence to users. ATM makes efficient use of bandwidth and is used in both LAN and WAN environments to provide seamless connectivity.

3.1. Historical Development

DSTO's research into the area of ATM began in 1989. Shortly after, a Memorandum of Understanding (MOU) for collaboration in ATM research was signed with Telecom Research Laboratories (TRL) in Melbourne. This collaboration has allowed each organisation to monitor the other's forward network planning processes, which is important in ensuring that future Defence and Civil networks maximise interoperability with one another.

TRL and DSTO jointly developed a TRL-designed ATM switch to explore the usefulness and capabilities of this technology. A research testbed was constructed with switch nodes at the Adelaide and Melbourne premises of the two organisations. The two sites are connected via a dedicated 34Mb/s optical fibre and the first ATM traffic successfully passed between them in April 1993. Since it came into operation, the network has been used extensively to demonstrate multi-media communications capabilities. These demonstrations involve video conferences combined with shared user applications to illustrate the network's capability to support a mix of differing types of traffic. They generally take the form of Command & Control or disaster relief scenarios involving cooperative activities in Adelaide and Melbourne. Additionally, the testbed permits the exploration of techniques and strategies suitable for use by future military and commercial users and enables their interests to be represented in the development of standards for the new technology.

3.2. Switch Architecture

A simplified view of the switch node architecture is shown in Figure 1. It consists of a self routing switch fabric surrounded by port controllers which perform the function of cell header translation. These are preceded by trunk controllers which cater for particular types of user traffic while presenting a common interface to the port controllers. The trunk controllers also insert and discard idle cells, and perform clock recovery, cell boundary delineation and header error checking.

The port controllers inspect the headers of incoming cells and translate them into a new 8 byte header. This consists of the standard 5 byte header with a prepended 3 byte header specifying the output port number and discard and delay priority. This information is obtained from tables set up by the port manager which are accessible to the port controllers. The port controllers are implemented with fast 32 bit digital signal processors, the code for which is downloaded at switch initialisation.

The Node Controller provides the switch user management interface and is responsible for the setup of switched virtual circuits within the network. To do this, signalling messages are sent to the switch and routed as ATM traffic via a reserved virtual connection to the Port manager of the switch to be configured. The Port Manager decodes the message and causes appropriate changes to be made to the Port Controller header translation tables.

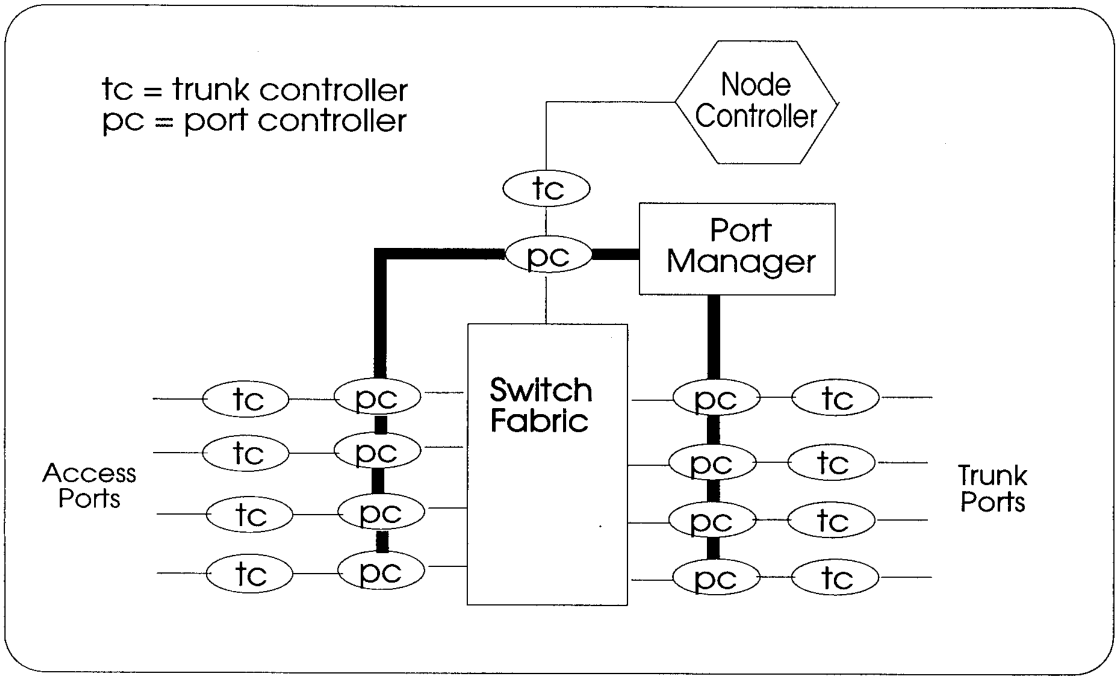

Figure 1 : Switch Node Architecture

The Switch Fabric can handle 32 I/O ports and consists of eight parallel planes of Omega switching networks in parallel. These are preceded by filtering and sorting hardware which directs cells to alternate switch planes if blocking would otherwise occur due to contention within the fabric. Cells with the lowest discard priority are dropped if contention for one output port exceeds eight. The fabric supports 4 levels of discard priority and 4 levels of delay priority in each of its 32 ports. For more information and technical details on the DSTO/TRL ATM Network see [1].

4. Current configuration

Presently, the Research ATM Network spreads across four capital cities in the south-east of Australia. In addition to the Adelaide and Melbourne sites already mentioned, the network is also accessible from Canberra and Sydney. Figure 2 shows the current arrangement.

4.1. Network Hardware

Three of the sites mentioned above contain ATM switch nodes. The exception is Telecom in Sydney which simply serves as a remote terminal to the TRL Melbourne switch.

The original jointly developed experimental ATM switches are located at DSTO Adelaide and TRL Melbourne. DSTO Adelaide and DSTO Canberra each recently purchased General DataComm (GDC) APEX DV2 switches. The GDC switches provide an off-the-shelf capability to support low variable bit rate ATM cell based interfaces suitable for use with the links needed for military tactical trunk extensions (up to 2Mb/s via satellite and ISDN and around 2.4kb/s over HF radio). In addition to providing this much needed capability, their incorporation into the network provided an opportunity to implement the DORIC philosophy of incorporating commercial equipment into a military network.

Currently, there are numerous trunks linking these switches. There are 34Mb/s optical fibre links between Sydney and Melbourne and between Melbourne and Adelaide. Between Canberra and Adelaide there is a 256kb/s satellite link (capable of a maximum rate of 2Mb/s). Additionally, both sites are provided with ISDN Primary Rate Interfaces permitting dial-up connections to be made between each other or to other network nodes around the world. The use of reverse multiplexing equipment with the ISDN interface allows multiple B channels to be logically grouped into a single channel using a maximum of 30 B channels to Australian/European destinations or 23 B channels to the USA.

The satellite link is of particular interest since ATM cell based traffic on a satellite link can pose significant problems when a reliable higher layer transport protocol such as TCP is used. Errored headers or buffer overrun conditions arising due to excessive peak cell arrival rates cause ATM switches to discard cells. The use of ATM therefore increases the number of mechanisms that give rise to data loss.

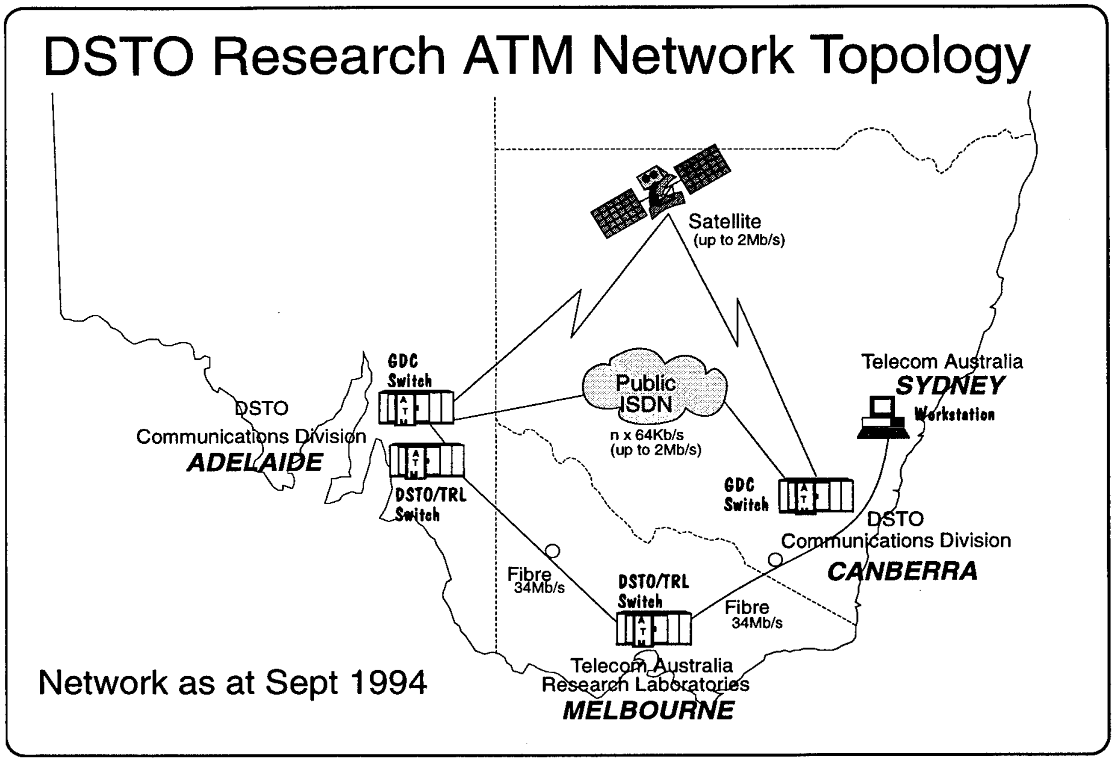

Figure 2 : Current Configuration

To enable continuous transmission, a TCP retransmission window must be of a size at least equal to the number of bits in the link. This is known as the delay bandwidth product and as an example, a geosynchronous satellite link with a bit rate of 1Mb/s and a propagation delay of approximately half a second would have approximately 500K bits or 65K bytes in the air at any time. The loss of a cell can significantly reduce throughput due to the subsequent retransmission of an amount of data up to the size of the window. The problem worsens with multiple TCP connections on the link, since congestion increases the likelihood of cell loss and the resulting retransmissions add further to the congestion problems. For more information on this topic see Ref. [2]. At DSTO the problem is being examined both by modelling techniques and by physically examining and characterising the problem using the ATM satellite trunk between Salisbury and Canberra. This is a well known problem and investigations conducted elsewhere in the world are monitored.

4.2. Current Applications

There are several applications which are run to demonstrate the multi-media capabilities of the Research Network. The DSTO/TRL switches in Adelaide and Melbourne are used to bridge ethernet LANs at each site. Multi-media applications are run between Sun workstations on opposite LANs with virtually the same performance as if they were both local. Examples of applications demonstrated are shared whiteboard, video telephony and distributed database software called the Graphics Hypermedia Information System (GHIS) which was developed by Information Technology Division (ITD) at DSTO. In addition to these LAN applications, each of Adelaide, Melbourne and Canberra have constant bit-rate video codec units which allow video conferencing to take place. These facilities are used to present audiences with Command & Control and disaster relief scenarios operating between Adelaide and Melbourne during network demonstrations. Video conferencing is currently used between Canberra and Adelaide and Canberra will soon have access to the LAN applications used for the Adelaide Melbourne demonstrations.

4.3. Areas of Research

Apart from the fields of investigation already mentioned, areas of research being conducted within DSTO include Packet Transport Modelling [3], ATM Traffic Estimation [4] and Burst Multiplexing Schemes [5]. DSTO also sponsors research in academic institutions from time to time.

5. Planned Extensions

The description of the DSTO Research ATM Network already given provides an overview of its current state. There are various plans for further enhancements and additions in order to support other areas of research. Figure 3 shows the components which will possibly make up the network in the future.

5.1. Canberra Extension

As well as the satellite and ISDN connections between Adelaide and Canberra, there will also be an HF radio link. In Australian tactical networks, HF radio is an integral part of the system, especially as a backup trunk for use when other higher rate trunks have failed. The data rate over such a link is only of the order of several Kb/s. Obviously, such relatively low rates will only support fairly simple services such as low rate voice, messaging or image transfer.

The question DSTO faces is how best to integrate an HF link into a wider ATM based network. It may be that it is too costly in terms of overhead to transmit information in

ATM cell format over the link. Regardless of the actual data format on the HF link, it should be integrated into the network to the degree that an end user can maintain a common operating environment and not have to physically move between equipment as different trunk bearers are used.

5.2. ITD Extension

Information Technology Division (ITD) in DSTO is concerned with investigating suitable applications and operating environments for the next generation of Defence networks. With this in mind they wish to connect to the DSTO Research ATM Network. ITD has groups working in both Adelaide and Canberra. In the near future, ATM based LAN hubs will be purchased for both sites to allow these groups access into the network. They will then be able to research high speed networking issues and investigate aspects of security in the higher layers of the OSI protocol stack.

5.3. TTCP Extension

The Technical Cooperation Program (TTCP) is an alliance formed to promote collaborative research into defence related issues by its member countries: Australia, New Zealand, United States, Canada and the United Kingdom. Sub-group 'S' is concerned with C^3 (Command, Control and Communication). This sub-group has agreed to create an international ATM testbed by connecting the various experimental Defence ATM networks already existing in each of these countries. This project is called the ATM Command and Control Operations and Research Demonstrator (ACCORD). Australia has a dial-up ISDN connection between the DSTO Research ATM Network and NRaD (US Navy R&D Division) in San Diego in the US. This will later be supplemented with a satellite link.

The purpose of this program is to investigate multinational interoperability issues. It is becoming more common for allied forces to become involved in international peace keeping activities and as a result there is an increasing demand for seamless communications between the forces of different nations. At the same time, each country still has its own security requirements for distribution and access to sensitive information, the level of which can vary over time. The ACCORD testbed will provide a framework for experimentation in these areas.

5.4. Support for the K-95 Military Exercise

Communications Division in DSTO is proposing a C^3 testbed to which real military users could have access. Besides providing practical demonstrations, the testbed could also assist in generating the complex user requirements of C^3 systems by helping to define and refine these through early prototyping, evaluation and quantification. As well, the testbed could be used to test and evaluate interim solutions and migration strategies, and finally it could assist with the equipment acquisition process.

This proposal would see several fixed and deployed Headquarters interconnected via a combination of ISDN and satellite bearers with ATM technology underpinning the network. The DSTO sites in Canberra and Adelaide would also form part of the testbed. An initial goal is to have a technology demonstration (which would be a subset of the full testbed) up and running during the K95 military exercises in August 1995.

The extensions to support the K95 exercise will support the exercise controllers overseeing the exercise through the provision of two deployable switches and peripheral equipment at Exercise Control Centre (EXCON) and the Orange Forces Headquarters (OFHQ) at a remote location off Darwin. EXCON, OFHQ and Canberra will be interconnected via meshed satellite links while a one-way (in only) link will connect Salisbury to the network. The network will provide a virtual ethernet functionality to workstations running exercise management software. Additional traffic will be provided by point to multi-point video conferencing, voice communications, image transfer and broadcast news and weather services (which will be provided by the Salisbury one-way link). Information gained from the logging of network traffic and performance will be of considerable value to DSTO network analysts in the determination of problem areas and the design of improved capabilities.

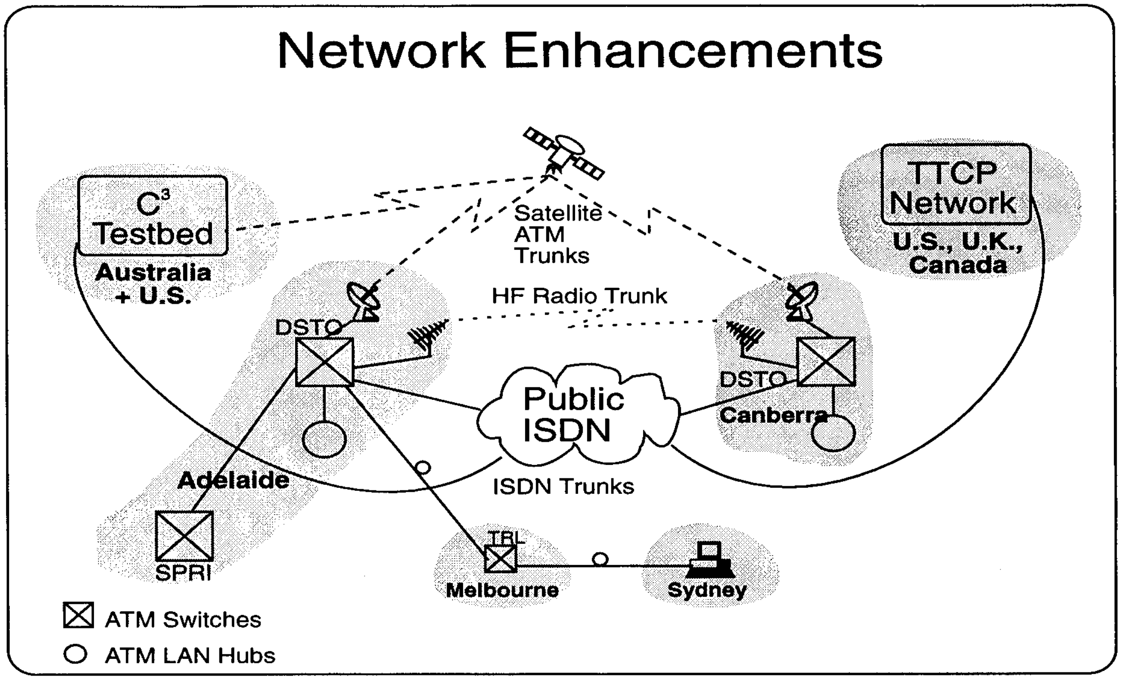

Figure 3 : Likely Network Extensions

5.5. Telecom Experimental Broadband Network (EBN)

Telecom Research Laboratories are about to launch an EBN service for user evaluation and experimentation. Nodes will be installed in Brisbane, Sydney, Canberra and Melbourne; linked together with 34 Mbps fibre interconnections. The currently used 34Mbps link between DSTO and TRL will become a DSTO tail to the Melbourne EBN node. Connectivity to TRL will then be via the Melbourne switch. DSTO at Fernhill Park in Canberra will be provided with a 34 Mbps link to the Canberra EBN node. Salisbury and Canberra will then have an effective 34 Mbps switched link between them

5.6. Connection with SPRI

A possible further extension is to the Signal Processing Research Institute at the University of South Australia. Such an extension would provide opportunities for postgraduate research on issues of mutual benefit to both the University and the ADF.

6. Conclusion

The DSTO Research ATM Network provides the opportunity to conduct research into aspects of next generation Defence communications networks not being immediately addressed within the civil arena.

The knowledge gained will be invaluable in the future network planning process to develop a goal architecture for Defence. It will also be relevant to forming the migration strategies which will outline the evolution of current networks to the future architecture.

7. References

[1] D. Kirkham and P. Shoubridge, *"The Telecom/DSTO Research ATM Network"*, Proceedings of Australian Broadband Switching and Services Symposium, Wollongong, July 1993, pp. 120-127.

[2] Allyn Romanov and Sally Floyd, *"Dynamics of TCP traffic over ATM Networks"*. Available via internet from playground.sun.com/tcp_atm/tcpatm_syn.04.ps

[3] P. E Berry, *"A Fluid Flow Model for the Performance of Packet Transport over ATM"*, Australian Telecommunication Networks and Applications Conference, Melbourne, December 1944.

[4] P. L. Slingsby, *"A New Approach to ATM Traffic Estimation"*, Australian Telecommunication Networks and Applications Conference, Melbourne, December 1944.

[5] Falzon, L. A., *" A Comparison of Burst Multiplexing Schemes"*, Australian Telecommunication Networks and Applications Conference, Melbourne, December 1944.

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19. Abstract

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